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1 Plant watering system

2

3 This invention relates to a plant watering system. In
4 particular, it relates to a plant watering system which
5 allows the long term watering of plants, without the need
6 for an open reservoir.

7

8 The watering of plants both in the home and commercially
9 poses an easily identifiable problem. For example, the
10 problem of providing a plant with water on a regular
11 basis is both time consuming and, in some instances, can
12 be difficult depending on the positioning of the plants
13 (i.e., above shop fronts, etc.) Also, over-watering of
14 plants can be a problem when a large quantity of water is
15 poured into the soil to try and cut down the number of
16 times a plant needs to be tended. There are also
17 problems when moving plants if there is an open reservoir
18 of water being used to keep them healthy, as movement or
19 container breakage can cause spillage of the water very
20 easily. Open water can also provide a breeding ground
21 for micro-organisms such as algae, worms, insects such as
22 maggots and flies which can cause and propagate plant
23 problems and include the mosquito which can propagate
24 human disease.

1
2 The prior shows a number of inventions that aim to
3 overcome the above mentioned problems. For example,
4 International Patent Application No W002/35918 in the
5 name Christopher Raymond Moran relates to apparatus for
6 cultivating plants where a vessel containing plant
7 cultivating medium has a number of apertures, and these
8 apertures are substantially covered by a water permeable
9 polymer which controls water entry into the vessel. The
10 vessel and polymer sit in a reservoir for the aqueous
11 media. However, it is worth noting that in this instance
12 a reservoir of liquid water is still required, causing
13 the problem of spillage during movement and the
14 possibility of contamination by micro-organisms. Also,
15 the versatility of the product is low, as the polymer is
16 included as part of the total vessel.

17
18 It is an object of the present invention to provide a
19 plant watering system which allows the long term watering
20 of plants without the need for frequent regular
21 attention.

22
23 It is a further object of the present invention to
24 provide a plant watering system where there is no open
25 reservoir of water, therefore reducing the likelihood of
26 spillage and/or contamination by micro-organisms.

27
28 A yet further object of the present invention is to
29 provide a plant watering system which can be used on a
30 wide range of plants which have different water
31 requirements.

32
33 A yet further object of the present invention is to
34 provide a plant watering system that is flexible, in that

1 it can be used with a wide range of indoor and outdoor
2 pots and containers.

3

4 A yet further object is to provide a plant watering
5 system which can utilise unfiltered water from natural
6 rainwater or a wide bore feed, making considerable
7 savings with regard to filtration requirements.

8

9 A yet further object is to provide a plant watering
10 system which has a self regulating water charging
11 characteristic.

12

13 According to a first aspect of the present invention,
14 there is provided a plant cultivation system comprising a
15 water insoluble polymer contained with a porous bag or
16 enclosure.

17

18 Optionally the plant cultivation system is placed close
19 to the roots of plants growing in the ground.

20

21 Alternatively the plant cultivation system is placed
22 close to the roots of plants growing in pots or
23 containers.

24

25 Preferably the polymer is a neutral polymer.

26

27 Most preferably the polymer is a hydrogel.

28

29 Most preferably the hydrogel is a particulate hydrogel.

30

31 Most preferably the hydrogel is a hydrogel which retains
32 a high degree of rigidity at available degrees of
33 swelling with water.

34

1 Preferably the hydrogel is poly(ethylene oxide).

2

3 Most preferably the poly(ethylene oxide) is rendered
4 insoluble in water by physical or chemical cross-linking.

5

6 Preferably the hydrogel particles are between 100 microns
7 to 1cm in diameter.

8

9 Optionally, the polymer may contain additives.

10

11 One option is that the polymer may be coloured.

12

13 Preferably the polymer swells rapidly on contact with
14 water.

15

16 Preferably 1kg of dry polymer will store 3 to 20 litres
17 of water.

18

19 Most preferably the porous bag is rapidly permeable to
20 water.

21

22 Preferably the bag may be produced in different sizes, so
23 that it is suitable for a range of plants and containers.

24

25 Optionally, the bag may be produced in a range of
26 different shapes, so that it is suitable for a range of
27 plants and containers.

28

29 Optionally, the amount of polymer in a porous bag is
30 altered depending on the water requirements of the plant
31 for which it is to be used with.

32

33 Optionally the size of the pores in the exterior material
34 of the porous bag may have sizes as large as possible

1 without allowing the significant escape of the contained
2 particulate hydrogel.

3

4 Optionally, the porous bag is sealed by heat sealing.

5

6 Alternatively, the bag is sealed by stitching.

7

8 A further alternative is that the bag is sealed by glue.

9

10 Alternatively the bag may be sealed by one or more of the
11 abovementioned means.

12

13 Preferably the porous bag is produced from a material
14 with an air water surface contact angle below 90°.

15

16 Optionally, for plants with low water requirements, the
17 porous bag can be produced from a material with an air
18 water surface contact angle of greater than 90°.

19

20 Most preferably the porous bag is produced from cellulose
21 or a cellulose derivative.

22

23 Optionally, the porous bag may be knitted, braided, woven
24 or in the form of felt.

25

26 The term bag as used herein includes all porous
27 enclosures in which the containment is of an expandable
28 or conformable design. It can comprise in whole or in
29 part more rigid material with a section or mechanism
30 which can distort to adapt to an internal change in
31 volume due to the swelling or shrinking of the contained
32 hydrogel. It could, for example have a concertina design
33 using a rigid porous plastic or comprise a plant pot into
34 which an integral permeable and conformable fabric

1 sealing the hydrogel into a base or other containment are
2 intended.

3

4 According to a second aspect of the present invention,
5 there is provided a method of using the plant cultivation
6 system of the first aspect, wherein the plant cultivation
7 system is placed within a vessel containing a plant
8 growth medium and a plant.

9

10 Preferably the vessel does not contain any apertures on
11 the lower surface.

12

13 Alternatively, the vessel may contain apertures to allow
14 excess water to drain away or to enter. In this mode it
15 can exhibit self-regulating filling and refilling
16 properties thereby removing the need for operator
17 judgement or skill. It also allows the system to be used
18 out of doors without risk of over-watering and flooding.

19

20 According to a third aspect of the present invention,
21 there is provided a method of using the plant cultivation
22 system of the first aspect, wherein the plant cultivation
23 system is placed underneath a vessel containing a plant
24 growth medium and plant, and wherein the vessel contains
25 one or more apertures on the lower surface which is in
26 contact with the plant cultivation system.

27

28 According to a fourth aspect of the present invention
29 there is provided a method of using the plant cultivation
30 system of the first aspect, wherein the plant cultivation
31 system or systems is placed on or under capillary matting
32 in a container and a plant containing vessel is also
33 placed on the capillary matting and wherein the plant

1 containing vessel is provided with one or more apertures
2 in its base.

3
4 In order to provide a better understanding of the present
5 invention, example embodiments will now be described by
6 way of example only, and with reference to the
7 accompanying Figure, in which:

8
9 Figure 1 shows a cross-sectional view of a plant
10 cultivation system according to the first aspect of the
11 present invention;

12
13 Figure 2 shows an expanded view of water soluble polymer
14 in its preferred form according to the present invention;
15

16 Figure 3 shows a plant cultivation system in use
17 according to one aspect of the present invention;
18

19 Figure 4 shows a plant cultivation system in use
20 according to another aspect of the present invention;
21

22 Figure 5 shows the plant cultivation in use according to
23 a yet further aspect of the present invention; and
24

25 Figure 6 shows a yet further embodiment of the present
26 invention.

27
28 In the preferred embodiment of the present invention,
29 there is provided a plant cultivation system which allows
30 the long term watering of plants without the need for an
31 open water reservoir. The plant cultivation system 1 is
32 made from a water insoluble polymer which, in the
33 preferred embodiment, is a water swellable hydrogel 3.
34 The water soluble hydrogel is contained within a porous

1 bag 2 which is made of material which can contain the
2 hydrogel 3 and which is also rapidly permeable to water.
3 This means that if water is poured on to the plant
4 cultivation system 1, it immediately travels through the
5 porous bag 2 and into the hydrogel 3, wherein the
6 hydrogel 3 rapidly swells up upon contact with the water,
7 therefore storing the water in a solid form. An example
8 of the plant cultivation system 1, according to the
9 present invention, can be seen in Figure 1.

10

11 In the preferred embodiment, the hydrogel 3 is made up
12 from a number of particles 4. This is opposed to a solid
13 amount of hydrogel 3. As the hydrogel 3 is particulate
14 in form before and after swelling, as can be seen in
15 Figure 2, it is able to take in water very rapidly due to
16 the large surface area and porosity available. It also
17 adds ventilation of water in vapour form as well a liquid
18 form.

19

20 The plant cultivation system 1 therefore is able to hold
21 a reservoir of water in solid form, which can be made
22 available to a plant as the plant requires it. It can be
23 seen that the plant cultivation system 1 can be made in a
24 variety of different shapes and sizes, depending on the
25 intended use for the system 1. For example, for window
26 ledge pot plants, only a small plant cultivation system 1
27 would be required, whereas for arrangements for
28 commercial uses, i.e., in office blocks, etc., larger or
29 specially shaped plant cultivation systems 1 may be
30 required. Also, the plant cultivation system 1 can be
31 produced with different amounts of hydrogel 3 in
32 different sized porous bags 2. Placing more or less
33 hydrogel 3 into the same sized bag 2 would alter the
34 water potential, so that different plant cultivation

1 systems 1 with different water potentials can be
2 produced, making them appropriate for different plants.
3 For example, plant cultivation systems 1 could be
4 produced specifically for plants which have low water
5 requirements, or specifically for plants which have high
6 water requirements, depending on the water potential in
7 the bag. The ratio of water to hydrogel 3 will also
8 determine the amount of water to add, and each plant
9 cultivation system 1 can be provided with guidelines
10 indicating the preferred water content for particular
11 plants.

12

13 Any known hydrogel 3 can be used in the plant cultivation
14 system 1. For example, polyacrylamide, polyacrylic acid,
15 polyvinyl alcohol, polyvinylpyrrolidone and acetylated, --
16 etherified or grafted celluloses can all be used.
17 However, the preferred embodiment uses poly(ethylene
18 oxide) which has been rendered insoluble in water by
19 chemical or physical cross-linking. This hydrogel is a
20 rubbery hydrogel that is able to shrink and expand
21 without the problem of cracking. It is also a neutral
22 polymer, which means it has no negative effects on the
23 plants, and also does not leach ions from water, which
24 may be required by a plant. For example, the neutral
25 character of poly(ethylene oxide) is less prone to
26 specific ion absorption of Ca^{2+} ions, and as Ca^{2+} ions are
27 required for shoot and root growth and development, this
28 can be very important. Also, poly(ethylene oxide) does
29 not shrink significantly in the presence of dissolved
30 ionic species such as fertilisers or salts.

31

32 Also, mixtures of different hydrogel compositions can be
33 utilised.

34

1 The preferred embodiment also allows for additives to be
2 included into the hydrogel which may be beneficial for
3 plants, and also additives such as colourants which would
4 distinguish the hydrogel 3 or protect it against UV
5 light.

6

7 The porous bag 2 in the present invention can be made of
8 any appropriate porous material of adequate strength.
9 Either single material types or mixtures of materials can
10 be used to make the bag 2. In general, it is preferred
11 to use a material with a surface contact angle below 90°,
12 which allows capillary or diffusive passage of liquid
13 water and also of vapour. In the preferred embodiment,
14 cellulose is used to produce the porous bag 2. The
15 cellulose is a staple fibre and in the preferred
16 embodiment the cellulose material is in the form of felt
17 or is knitted, braided or woven. In other embodiments,
18 cellulose derivatives can be used, such as cellulose
19 acetate.

20

21 Although the preferred embodiment uses a material with a
22 surface contact angle below 90°, in the case of plants
23 which have a very low water requirement, an alternative
24 embodiment can be used where the porous bag 2 is produced
25 for a material which has a high surface contact angle
26 (i.e., above 90°). In this embodiment, micro-porous
27 polythene can be used, as this will usually prevent
28 liquid water from passing through, but will still allow
29 water vapour to pass through. Many other polymers are
30 known to those skilled in the art, which would similarly
31 allow the passage of water vapour rather than liquid
32 water. When using the larger particle sizes such as 1cm
33 particles it is possible to utilise plastic netting such
34 as is used commonly on the packaging of fruits and

1 foodstuffs for commercial sale. A large variety of such
2 packaging materials are well known to those skilled in
3 the art.

4
5 In any of the embodiments, the hydrogel or water soluble
6 polymer 3 must be put into the porous bag 2, and the
7 porous bag 2 must be sealed in some manner. Sealing of
8 the porous bag 2 may be through melting, heat sealing,
9 gluing or stitching.

10
11 The plant cultivation system 1 can be used in a number of
12 different ways. Examples of these can be seen in Figures
13 3, 4 and 5. Figure 3 shows the plant cultivation system
14 1 being placed in the bottom of a pot 5, which is solid
15 other than for the opening at the top for the plant 7.
16 Plant growth medium 6 is placed on top of the plant
17 cultivation system 1, and the plant cultivation system 1
18 provides a reservoir of water which provides moisture to
19 the plant 7 as and when it needs it. It is also worth
20 noting that the system means water evaporation is slower
21 than it typically would be if the pot 5 only contained
22 plant growth medium 6. This mode of use provides "bottom
23 watering" which is generally considered desirable in the
24 industry. Some plants require "bottom watering".

25
26 Figure 4 shows another pot which has a plant cultivation
27 system 1 placed within it. However, in this case the pot
28 5 has apertures 9 at the bottom and sits in a container 8
29 into which water can be poured to top up the reservoir in
30 the plant watering system 1.

31
32 Another manner in which the plant cultivation system 1
33 can be used is by placing a pot 5 which contains
34 apertures 9 on the lower surface in contact with the

1 plant cultivation system 1. The plant 7 is placed in the
2 pot 5 along with plant cultivation media 6 and is able to
3 draw up water from the plant cultivation system, as and
4 when required.

5
6 It can be seen that there are various other embodiments
7 for which the plant water system can be used. For
8 example, the plant watering system 1 can be formed in a
9 pot-shape itself that is able to fit into a typical plant
10 pot 5. This can be seen in Figure 6. Here the edges of
11 the plant cultivation system 1 can be regularly topped up
12 with water, without the necessity of pouring the water
13 into the plant growth medium 6.

14
15 Also, the plant cultivation system 1 can simply be used
16 as a back-up in cases where another continuous watering
17 system is already in place. For example, if a valve is
18 being used to allow water into the plant cultivation
19 medium, the plant cultivation system 1 would typically be
20 in a continuously fully swollen state with water simply
21 passing through it. However, if the valve system failed,
22 there would be a reservoir of water which would keep the
23 plants well and healthy until the normal watering system
24 is fixed.

25
26 If a pot 5 with apertures 9 in the base incorporates a
27 plant cultivation system 1, then the system will charge
28 itself with a repeatable self-regulating quantity of
29 water. Any excess water would flow through the apertures
30 9 and can be seen in a tray or container into which the
31 entire assembly can be placed. The presence of excess
32 indicates that the cultivation system is fully and
33 reproducibly charged with water. This mode of operation
34 also removes the possibility of significant overwatering.

1

2 Examples

3

4 *1. Preparation of the poly(ethylene oxide) hydrogels.*

5 The preparation of poly(ethyleneoxide) hydrogels is well
6 described in the patent and general literature(e.g
7 Polymeric Material,s GB 2235462 B, Neil Bonnette Graham
8 and Christopher Raymond Moran ; N.B.Graham in
9 "Hydrogels for Useful Therapy",pages 79-97 of "High Value
10 Polymers", ed. A.H.Fawcett,Royal Society of Chemistry
11 Special Publication No.87,1991). These materials can be
12 prepared with a range of water swelling which increases
13 with increasing poly(ethylene oxide) content. They can be
14 granulated using conventional grinding equipment, by dry
15 or wet grinding combined with sieving to provide
16 particulate materials useful in the examples below.
17 Other hydrogels are commercially available in a
18 particulate form and may be purchased commercially.

19

20 *2. Preparation of the plant watering system of this*
21 *invention.*

22 Capillary matting commonly used in the horticultural
23 industry was purchased and cut into appropriately sized
24 circular sections. Two of these sections were then
25 stitched together around the outer perimeter leaving a
26 two-three inch opening on one section of the perimeter
27 only.A shaped bag with an opening was thus created.
28 Through this opening a weighed amount of granulated
29 hydrogel was inserted through a powder funnel. The weight
30 of the hydrogel was selected to store the desired
31 quantity of water for the specified reservoir storage
32 volume of water, in a solidified form. Thus for a
33 hydrogel which takes in five times its weight of water, a
34 1kg charge would produce a 5litre reservoir for water.

1 Similarly 2kg would produce a 10litre reservoir. The
2 manufacturing procedure is similar to the manufacture of
3 an upholstery cushion and the products may be readily
4 made in a variety of forms. The capillary matting bag is
5 designed to have enough volume to be filled with the
6 water-swollen hydrogel. The initial charge of dry
7 hydrogel does not fill the containing bag. When water is
8 poured onto the dry cushion it swells up like a balloon
9 and provides the solidified water reservoir.

10 The ratio of the bag volume to the weight of hydrogel
11 charged can be used to reduce the degree of water
12 swelling of the contained hydrogel. Lower degrees of
13 swelling can provide lower soil water levels suiting
14 plants desiring drier soil conditions.

15

16 The technology for placing particles into porous bags
17 accessible to water is well known and has been
18 particularly well developed in the field of tea bags.
19 Inexpensive fine porous bags of many different sizes and
20 shapes are commercialised and well known. Large scale
21 commercial equipment for such bagging is available and
22 well developed. Inexpensive light weight but strong non-
23 woven and heat-sealable fabrics are commonly used though
24 many different materials are well known.

25

26 *3. Different plants have quite different soil water*
27 *content requirements and transpiration rates.*

28 Some plants don't mind their roots being in liquid water
29 while others only thrive under quite dry soil conditions.
30 Yet others thrive under a wide range of soil conditions
31 and are very robust. Up to this present invention,
32 watering systems to provide long-term watering and also
33 buffering of the soil at a humidity level suitable for
34 the different plant root humidity requirements have not

1 been available. This plant watering system now allows
2 this highly desirable objective to be met. The examples
3 below illustrate that the system can provide long term
4 watering capability with different and desirable soil
5 humidity levels for six plant types: Dracaena, Kentia
6 palm , Peace Lilies(Spathiphyllum), Scindapsus,
7 Schefflera and Ficus.

8

9 Example 3.1 -Dracaena Janet Craig

10 Dracaena Janet Craig is a plant, with a low water
11 transpiration. Two plants of Dracaena Janet Craig were
12 potted up by a commercial interior landscaping company by
13 professional horticultural technicians who subsequently
14 looked after the plants. The plants were located in a
15 commercial office. One of the plants contained a 5litre
16 hydrogel bag reservoir, prepared as in Example 2 above
17 while the other, the control did not and both were made
18 up with identical compost according to best commercial
19 practice. The technicians assessed the need for plant
20 watering by assessing the feel of the compost and the
21 appearance of the plant. The normal watering cycle in
22 this case would have been at approximately two-weekly
23 intervals. At the outset the plant pot containing the bag
24 reservoir was given 5litres of water. The control was
25 given the amount judged to be optimum from previous
26 experience. During the next 69 days it was found
27 necessary to water the control plant another three times
28 while the pot containing the bag reservoir only required
29 one (much larger) watering at forty days. The plants in
30 both plants were in good health and appearance and the
31 soil humidity measured by a Theta meter remained high and
32 similar in both systems.

33

1 The bag reservoir system clearly would allow watering at
2 intervals of six weeks as compared with 2-3 weeks for the
3 conventionally watered control.

4

5 Example 3.2 - Dracaena Dermensis Lemon Lime

6 A Dracaena Dermensis Lemon Lime plant of approximate
7 height 2 feet, was potted in compost into a plastic pot
8 with a holes in the base. It was placed inside a larger
9 pot into which a 1litre reservoir bag was placed and
10 charged with one litre of water. The pot containing the
11 plant was pressed down onto the previously weighed
12 reservoir bag and at intervals and left in a domestic
13 conservatory. The health of the plant was monitored , the
14 reservoir bag was weighed as was the plant with soil and
15 pot. The soil humidity was measured on the same occasion
16 with a Westminster soil moisture meter which measured the
17 soil moisture level on a range of 0-10. Three separate
18 soil moisture readings were taken at different locations
19 within the pot and the results averaged. When water was
20 provided it was through the pot containing the plant.
21 This ensured that the soil was thoroughly wetted. The
22 weight loss of the system was used to calculate the daily
23 weight loss which equates approximately to the
24 transpiration of the plant.the trial was started on the
25 23-July 2002 in the summer. At 36 days the plant was in
26 good condition even though the roots had grown out of the
27 bottom of the pot and appeared dry. The average daily
28 weight loss for the period was 11.7g/day. The reservoir
29 bag still felt damp to the touch and was found to have
30 lost 420g of water over the period which was less than
31 half of the water initially charged. One litre of water
32 was added to the pot onto the top soil surface. It
33 charged the reservoir bag with no visible liquified water

1 to be seen. At 69 days the plant was in good condition
2 apart from slight browning of three leaf tips.
3
4 Considerable new shooting was evident. The soil was very
5 dry and gave a reading of zero on the moisture meter. The
6 roots had however grown into the reservoir bag at this
7 point and the plant throughout the trials seemed to
8 thrive under these conditions. Only 280g of the water in
9 the bag remained. The effective daily water loss over the
10 period was approximately 14.5g/day. A further one litre
11 of water was applied to the top of the pot and after a 10
12 minute delay the average moisture reading was 4. The
13 plant was not watered again until 181dayswhen the
14 moisture reading was 0.8. There remained more than half
15 of the last-charged water and the calculated
16 "transpiration" rate over the period was 16g/day. Over
17 the 181 days only three waterings had been required.
18 The conformation of the reservoir and the pot were now
19 changed. The plant was removed from the pot and placed in
20 a different ceramic pot without any holes in the base. To
21 allow the plant to be placed in the pot to the
22 appropriate depth the same reservoir bag as previously
23 used was placed in the pot at the side of the plant
24 roots. This provided a simple view of the top of the bag
25 level with top of the compost and allowed the water
26 content to be assessed by sight and touch. 1 litre of
27 water was added and the pot and contents weighed. It was
28 estimated that the pot contained 1640g of water which
29 would be expected to last approximately 100days at the
30 previously measured rate of transpiration. The plant was
31 left for 113days before checking and watering. On
32 weighing it was found that the system had lost 1030g
33 which equates to a rate of 9.1g/d. The average moisture
34 reading was 0.2. The compost was dry and crumbly. In

1 spite of these apparently dry conditions the plant looked
2 to be in good health and still had new shoots. A further
3 litre of water was added. It was assessed again at
4 160days when the weight loss over the period measured
5 1180g and the soil humidity was 0.2. The interval was
6 only 47days but the average transpiration had doubled to
7 25.1g/d. It now being May this was thought to be due to
8 the increased metabolism due to Spring conditions. The
9 plant was of very good appearance and showed considerable
10 growth and new shoots.

11

12 1.4litres of water and 2 caps of Miracle Grow liquid
13 plant feed were added. At 188days The weight loss was
14 1.2kg and the soil humidity was 0.1, the average
15 transpiration had risen again to 42.9g/d over the 28days
16 interval. 1.5litres of water were added and four caps of
17 the same liquid fertiliser. The moisture reading after
18 standing for ten minutes was 7.9. At 218days the plant
19 was still in excellent condition and the test was
20 discontinued. It is clear that the quite modest bag
21 reservoir system satisfactorily maintained the plant with
22 watering intervals in the range one to three months
23 depending on the time of the year. It was also clear that
24 the soil moisture measurement can reach the very low
25 values of 0.1 without damage to the plant. It was assumed
26 that once again the roots had penetrated the reservoir
27 bag and was able to access the available water.

28

29 Example 3.3 - Howia Kentia Palm

30 A 5 litre water capacity reservoir bag was made by
31 introducing 1kg of a crosslinked poly(ethylene oxide)
32 based polymer with a water uptake of five times its dry
33 weight, into a circular bag made from capillary matting
34 as described in Example 2 above. This bag was soaked and

1 drained in water when it took up and retained 5kg of
2 water providing a 5kg water reservoir. This water-filled
3 reservoir was placed in the bottom of a large plastic
4 circular planter-pot without any bottom drainage holes. A
5 three foot high healthy specimen of Howea Kentia Palm was
6 potted up on top of, and in capillary contact with, the
7 bag reservoir. John Innes No. 3 compost was used for the
8 potting. The top surface of the soil in the planter was
9 covered by an inch deep layer of coarse white marble to
10 provide a decorative effect. One cap of BabyBio liquid
11 fertilised feed was sprinkled over the surface. The
12 weight of the total pot+water+compost+plant was taken.
13 The plant was placed in a domestic lounge, close to a
14 large window, in a centrally heated house. The trial
15 commenced in Scotland in the summer of 2002 (25 June). The
16 general appearance of the plant was monitored by visual
17 inspection and weighing the total system from time to
18 time to measure the weight loss which was taken to be an
19 approximation to the transpiration and indicated the
20 water usage and water requirement. After 64 days the plant
21 looked in good health with new shoots at the base and
22 growth at the top. The weight loss over this period was
23 4.5kg indicating a daily rate of loss of 70.3g/d. 5 litres
24 of water were added to the top surface, the system was
25 reweighed and left for a further period. After an
26 interval of 69 days and a total elapsed time of 133 days
27 the weight loss was 5.4kg. The average moisture meter
28 reading was 2.4. 5 litres of water were added and after 10
29 minutes the moisture meter average was 10. Three small
30 older fronds were removed as they contained a few
31 browning leaves. There was considerable fresh new growth.
32 The season was now entering winter. The plant continued
33 to look healthy with new growth. After a further interval
34 of 92 days (total elapsed time of 225 days). The plant

1 still looked healthy. The weight loss over the 92 days
2 was found to be 3.5kg so 3.5kg water was added to the
3 pot.

4
5 After a further period of 101 days (total elapsed time
6 326 days) the weight loss was 6.2kg and the soil average
7 humidity reading was 0.3. One new leaf and one older one
8 had some brown tips or brown patches. Otherwise there
9 were no defects and the plant continued to look healthy.
10 Seven litres of water and 3 caps of Miracle Grow liquid
11 plant food were added which maintained the plant until
12 beyond the full year of the test.

13 These results were confirmed by a number of other similar
14 but less rigorously monitored tests on the same plant
15 species.

16
17 These results demonstrate that the bag reservoir can
18 sustain in good health, Howea Kentia palm plants using
19 watering intervals of from 64 to 101 days. A 60 day
20 watering interval used throughout the year will provide
21 satisfactory watering. The healthy survival of the plant
22 under even extremely dry soil conditions can be readily
23 understood if the roots have penetrated into the
24 reservoir bag as would be expected, and are able to
25 access the remaining water there concentrated.

26

27 Example 3.4 - Scindapsus

28 In experiments run in the same manner as for the Kentia
29 palms in example 1.3. Two good quality Scindapsus plants
30 of initial height 4 feet, were potted up with John Innes
31 NO.3 compost over a 4litre and an 8litre bag reservoir
32 containing granulated hydrogel comprising predominantly
33 poly(ethylene oxide). A solid pole was used as a support
34 for the growing plant. They were placed near windows in

1 a very sunny conference room which was centrally heated.
 2 The reservoirs were charged with the appropriate 4l and
 3 8l of water before the potting. The pot weights, water
 4 added and soil humidities were measured over three
 5 months. The water used, the water remaining in the pots
 6 were calculated over the three months of the test. .The
 7 results are given in the tables below The pants were
 8 healthy at all times and showed vigorous new growth
 9 without any signs of wilting at any stage.

10

11 Scindapsus 8 litre reservoir.

12

Date of visit	Plant No	Total weight (kg)	Soil humidity	Water added (l)	Water left in system (l)	Water used(l) since last observation
13-Mar	5	33	4.1	0	x	x
02-Apr	5	30	3.1	0	6	x
15-Apr	5	29.5	2	4	5.5	0.5
23-Apr	5	33	4	0	9	0.5
30-Apr	5	31	3.5	0	7	2
08-May	5	30.9	3.5	0	6.9	0.1
16-May	5	30.28	3	0	6.28	0.62
23-May	5	29.66	2.5	0	5.66	0.62
06-Jun	5	29.42	2	0	5.42	0.24
18-Jun	5	28.92	2	0	4.92	0.5
26-Jun	5	28.62	1.5	0	4.62	0.3

13

14 Scindapsus 4 litre reservoir.

15

Date of visit	Plant No	Total weight	Soil humidity	Water added	Water left in	Water used (litres) since last observation
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		(kg)		(litres)	system (litres)	ce last observation
13-Mar	6	25	4.1	0	x	x
02-Apr	6	21.5	4	0	1.5	x
15-Apr	6	21	2	4	1	0.5
23-Apr	6	25	4	0	5.5	0.5
30-Apr	6	24	3.5	0	4.5	1
08-May	6	22.52	3	0	3.02	1.48
16-May	6	21.88	3	0	2.33	0.69
23-May	6	21.28	2	0	1.78	0.55
06-Jun	6	21.02	2	0	1.52	0.26
18-Jun	6	20.28	2	0	0.78	0.74
26-Jun	6	20.12	2	0	0.62	0.16

1
2 The average daily water loss was approximately 75g/d and
3 both the 4l and 8l reservoirs were able to provide for
4 all of the water needs of both plants during the Spring
5 season. Only one addition of 4l water each was required
6 to each pot during the 3 months. The 8l reservoir plant
7 still contained 4.6l water which should provide for at
8 least a further month without any extra water being added
9 (even recognising that this figure includes a significant
10 error for the amount of water and the CO₂ fixed by the
11 growth of the plant). These results indicate very clearly
12 how the increase of the reservoir size does not cause any
13 problem to the plants and does not significantly alter
14 the rate and total of water loss but simply provides a
15 larger water supply and allows longer intervals between
16 watering to be designed into the plant pot by choice of
17 the reservoir size.

18

19 Example 3.5 - Schefflera Gold Cappella

20 Similar tests to example 3.4 were made using Schefflera
21 Gold Cappella plants. Using an initial reservoir charge

1 of 4l water with 3 caps of Miracle Grow liquid fertiliser
2 only one extra watering of 2.5l was required over a
3 period of six months from January to July. The plants
4 looked very healthy with a lot of new growth. The plant
5 height increased approximately 12 inches.

6

7 Example 3.6 - Ficus Benjamina

8 Ficus Benjamina is a species which quickly shows it is
9 short of water by dropping its leaves and is difficult to
10 maintain without so doing. A 4 foot high variegated
11 Ficus Benjamina was purchased and maintained in the pot
12 in which it was bought. It was placed in a larger ceramic
13 pot which had no drainage holes in the base in the bottom
14 of which was a fully charged eight litre hydrogel bag
15 reservoir. The pot containing the Ficus was placed on top
16 of the bag reservoir so that capillary contact was
17 established via the holes in the base of the Ficus pot. A
18 marker stick was placed alongside the bag reservoir and
19 the position of a mark on the side of the pot recorded on
20 the stick for the fully charged and empty reservoir. The
21 amounts of water remaining in the reservoir was readily
22 measured by observing the position of the mark on the pot
23 against the upper and lower marks on the stick. The
24 system was placed on a sunny window ledge and monitored
25 over a period of a year. The plant was at all times
26 healthy sending out new shoots and it grew approximately
27 two feet in height. When the reservoir water level fell
28 to approximately half full water was added to the gap
29 between the inner and outer pots to bring it back to a
30 filled or almost filled state. The mark on the pot and
31 the top mark on the stick were aligned in this condition.
32 This was done approximately every two months. The Ficus
33 plant showed very little shedding of its leaves during
34 this period even during hot spells of weather. The roots

1 of the plant had penetrated into the reservoir bag and if
2 one lifted the plant from the base the reservoir bag came
3 up with it.

4

5 This experiment demonstrates a different method for
6 feeding water to the plant and measuring the water
7 content of the reservoir. Being solidified, no liquid
8 water is present and if desired for different plants, the
9 reservoir could be allowed to only contain a fraction of
10 its total capacity. This method of operation prevents
11 over watering and allows the reservoir to act as a
12 moisture buffer for plants requiring drier soil
13 conditions.

14

15 Example 3.7 - Peace Lily

16 Peace Lilies are particularly useful plants for the
17 evaluation of watering as they quickly indicate a
18 shortage of water from the sagging of their leaves. They
19 recover if watered soon after the sagging.

20

21 Three very large Peace Lilies (approximately 3 feet tall)
22 were separately potted up in two large circular
23 fibreglass commercial display containers containing in
24 one a four litre and in the other an eight litre bag
25 reservoirs fully charged with water. These containers did
26 not have drainage holes in their bases as they were of
27 the type intended for interior landscaping. The water
28 transpiration of these plants is so high that in spite of
29 their very desirable appearance are rarely used as they
30 are difficult and expensive to maintain without leaf sag.
31 The two plants were placed in a large-windowed centrally
32 heated lounge in a commercial building.

1 The results are given below. The 8litre reservoir system
 2 maintained the flowering plants in good health and
 3 appearance with no sagging of the leaves at all times
 4 during the trial. The four litre bag maintained the
 5 plants well but on three occasions leaf sagging was
 6 observed. These corresponded to the occasions when there
 7 was a hot spell and the water left in the system had
 8 fallen to less than 0.4 litres and the soil humidity in
 9 two out of the three cases had fallen below 3.0. In these
 10 cases the watering interval was 23days, 20 days and 14
 11 days which is very good for these plants. These results
 12 demonstrate the ability of the plant maintenance system
 13 to sustain these high water demand plants over long
 14 watering intervals and that, with the appropriate choice
 15 of the reservoir storage capacity, can provide confidence
 16 in their use over these prolonged periods without the
 17 poor appearance of sagging leaves.

18 *Peace Lily; 4 litres reservoir*

Date of visit	Plant No	Total weight (kg)	Soil humidity	Water added (l)	Water left in system (l)	Water used (l)
13-Mar	3	21	4	0		
02-Apr	3	20	4	4	3	
15-Apr	3	19	3.5	2	2+2	
23-Apr	3	19	3.5	2	2+2	
30-Apr	3	19	3.5	0	2	
08-May	3	22.18	4	0	2	
16-May	3	20.06	3	4	0.06	2.12
23-May	3	22.2	4	4	2.2	1.86
06-Jun	3	20.02	3.5	8	0.02	6.18
18-Jun	3	22.18	4	0	2.2	5.84
26-Jun	3	20.34	2.5	8	0.36	1.84

02-Jul	3	26.72	4	0	6.74	1.62
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1

2 *Peace Lily, 8 litres reservoir.*

Date of visit	Plant No	Total weight (kg)	Soil humidity	Water added (l)	Water left in system (l)	Water used (l)
13-Mar	4	21.5	4	0	x	0
02-Apr	4	26.5	4.2	8		
15-Apr	4	24	4	2		
23-Apr	4	21		2		
30-Apr	4	20	2	0		
08-May	4	23.48	3	0	8.48	
16-May	4	21.04	3	4	6.04	2.44
23-May	4	23.02	4	4	8.02	2.02
06-Jun	4	20.64	3.2	8	5.64	6.38
18-Jun	4	23.84	4	0	8.84	4.8
26-Jun	4	21.26	3	8	6.26	2.58
02-Jul	4	24.44	3.5	0	9.44	4.82

3

4 *4. A Self-regulating watering system for interior and*
5 *exterior use.*

6 Capillary matting was purchased from a Do-It-Yourself
7 store and a rectangle of the fabric cut from it such that
8 when glued using a hot-melt adhesive around it's edges it
9 formed a rectangular container of 10 litres internal
10 volume. A short length of the edge was left open to
11 provide a filling hole through which was charged 1kg of a
12 poly(ethylene oxide) based hydrogel able to take up by
13 swelling five times its weight of water (5l). The bag was
14 swollen in water when it took on a "large sausage" shape
15 and when weighed was found to contain 5kg of water in the
16 reservoir.

17

1 The charged reservoir was placed in a large plastic plant
2 trough with two large drainage holes in its base. The
3 reservoir occupied approximately one half of the trough
4 volume.

5

6 The plant trough was made up with Levington number 3
7 compost and 20 flowering annual plants were planted into
8 it. The plants included white and pink petunia, lobelia,
9 verbena, apple blossom diastara and solaire. The plants
10 were placed in a domestic indoor conservatory during
11 June. After fourteen days two sets of plants; the petunia
12 and verbena, looked very healthy and were breaking into
13 flower. The diastara, lobelia and solaire which were
14 already in flower were showing slight signs of shortage
15 of water but recovered when water was added. By weight
16 difference the trough had lost 5kg of water over the two
17 weeks. The average daily loss was thus 357g/day which is
18 very high. 6kg of water was added to the trough from the
19 upper surface and was absorbed so rapidly that it did not
20 come out of the drainage holes in the base of the trough.
21 After a further 12 days (26 days total elapsed time) the
22 plants looked very healthy and were flowering well. The
23 soil in the trough felt damp to the touch. At 29 days
24 however some of the plants the plants were beginning to
25 wilt. They recovered on watering. The measured water
26 loss over the 15 days interval was 7kg.

27

28 The trough was now placed outside so that it was open to
29 the elements and would be able to recharge itself when it
30 rained. It now acts as a patio planter. Excess water
31 would drain out through the drainage holes in the base of
32 the trough. In Scotland it did not need watering for
33 several months by virtue of the natural rainfall. The

1 plants continued to flourish and the trough did not
2 become waterlogged.

3

4 This example demonstrates the ability of the system to
5 maintain for two weeks, a considerable number of plants
6 under conditions which normally in a trough or hanging
7 basket would require watering every few days. It also
8 demonstrates the ability of the system to utilise natural
9 rainfall to recharge the reservoir. The reservoir will
10 maintain a filled charge of 5litres of water. If a tray
11 is placed under the trough indoors the appearance of any
12 significant amount of water in the tray when the water is
13 being added to the top shows that the reservoir is fully
14 charged.

15

16 Other similar experiments with floral hanging baskets
17 demonstrated that the baskets could be maintained without
18 watering for periods in excess of three weeks.

19

20 Conclusion

21

22 The six species of plants were chosen because they gave a
23 spread of water requirements, the Kentia Palms and the
24 Scindapsus take up an average amount of water and the
25 Peace Lily takes up a large volume of water over a short
26 period of time, if the soil of the plant runs low on
27 water it provides the dramatic visual effect of drooping
28 its leaves, thus making it difficult for IL companies to
29 service and provide this type of plant for clients.

30

31 All the plants are seen to be healthy and sending up new
32 shoots leaves and flowers in the warm summer period.

33

1 Laboratory Control Trial

2

3 The third of the trials were set up to monitor the bag
 4 system against a polystyrene placebo control. Two
 5 laboratory bred Ficus Benjiminias were selected as
 6 shedding of leaves is a common indicator for over or
 7 under watering of this species of plants. Plant A was
 8 potted up as normal with a block of polystyrene packing
 9 foam at the base in place of a water reservoir, 2 Litres
 10 of water was added. Plant B was potted up as above with
 11 a 1kg plant watering system, which contained 8 Litres of
 12 water. The ongoing results can be seen in Table below:

13

14 *Table: Control Ficus and 8-litre bag Ficus*

Date of visit	Plant A weight (kg)	Soil Humidity	Water added (l)	Plant B weight (kg)	Soil Humidity	Water added (l)
17-Feb	11.5	1.5	2	19	3.5	0
24-Feb	11.5	1.1	0	19	3.5	0
07-Mar	11	0.9	0	18.5	3.5	0
27-Mar	10	1	0	17.5	3.5	0
14-Apr	9	0.8	2	15	3	0
22-Apr	11	1.3	0	14.5	2.5	0
28-Apr	11	1.2	0	14	2	0
06-May	10.88	1	0	14.84	1.75	0
14-May	10.52	1	0	14.4	1.5	0
21-May	10.14	1	0	14.06	1	0
29-May	9.92	1	0	13.7	1	0
06-Jun	9.62	1	0	13.28	1	0
17-Jun	9.22	0.7	2	12.76	0.7	7
25-Jun	10.62	3	0	18.92	3	0

15

16 Conclusion

17

1 As can be seen by the results in the graphs and Table 8
2 above, the addition of an 8-litre plant watering systems
3 has reduced the frequency of watering of an identical
4 plant in the laboratory to one third of that of normal
5 hand watering. This is a significant improvement.

6
7 It can be seen that there are a number of benefits to
8 this invention, over and above the prior art. The
9 embodiments disclosed are merely exemplary of the
10 invention which may be embodied in various different
11 forms. Therefore, the specific structural and functional
12 details disclosed herein are not to be interpreted as
13 limiting, but merely as a basis for the Claims and for
14 teaching one skilled in the art as to the various uses of
15 the present invention in any appropriate manner. In
16 particular, the materials for the porous bag and hydrogel
17 as described in the embodiments should not be considered
18 as limiting, as alternative materials which have the
19 properties that are described as being required, could
20 also be used with the same effect.